



# Performance Analysis on a Double Pipe Heat Exchanger with Twisted Tape Insert Using $\text{Al}_2\text{O}_3$ -Water Based Nano Fluid

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## ABSTRACT

Heat exchangers are popularly used in industrial and engineering applications. Various heat transfer enhancement techniques are frequently used in a heat exchanger system in order to enhance heat transfer and increase in thermal performance of the system. With the help of inserting a twisted tape in the conventional heat exchanger, the higher heat transfer rate can be achieved. Heat transfer in a heat exchanger normally takes place with the help of conventional fluids such as water mostly because of its availability. Nanofluids, containing suspension of nano-meter sized particles have been reported to possess substantially higher heat transfer rate than their respective base fluids. In this project work, both the heat transfer enhancement techniques such as twisted tape and nanofluid have been taken to determine the heat transfer coefficients. The experimental analysis on the heat transfer characteristics of the double pipe heat exchanger with twisted tape insert using  $\text{Al}_2\text{O}_3$  –water nanofluid at 0.4% volume concentration has been done. The result showed that the combination of these techniques significantly increases the heat transfer coefficients than their individual use as an enhancement technique.

**Keywords:** Heat Exchanger, Nanofluids,  $\text{Al}_2\text{O}_3$

## 1. INTRODUCTION

The last few decades of the twentieth century have seen potential growth in communication, electronics and computing technologies, and it is likely to continue more rapid in the present century. The exceptional growth of these technologies and their devices through miniaturization and an enhanced rate of operation and storage of data have brought about serious problems in the thermal management of these devices. Another important area that has experienced a similar problem in thermal management is the area of optical devices. Lasers, high power X-rays and optical fibers are integral parts of today's computation, scientific measurement, and material processing, medicine and communication devices. The increasing power of these devices with the decreasing size also calls for innovative cooling technology.

There are several methods to increase the heat transfer efficiency. Some methods are like utilization of extended surfaces, application of vibration to the heat transfer surfaces, usage of micro channels and etc. It can also be improved by increasing the thermal conductivity of the working fluid. Commonly used heat transfer fluids such as water, ethylene glycol and engine oil have relatively low thermal conductivities, when compared to the thermal conductivities of solids. High thermal conductivity of solids can be used to increase the thermal conductivity of a fluid by adding small solid particles to that fluid.

The feasibility of the usage of such suspensions of solid particles with sizes in the order of millimetres or micrometres was previously researched by several researchers and significant drawbacks were reported. These drawbacks are sedimentation of particles, clogging of channels and erosion of channel walls, which prevented the practical applications of suspended solid particles in the base fluids as advanced technique in heat transfer applications. The better heat transfer rate can be achieved by enhancing the heat transfer capability of the fluid itself.

Modern nanotechnology provides new opportunities to process and produce materials with average crystallite sizes below 50 nm. As said earlier suspension of solid particles enhances the heat transfer, these nano-meter sized solid particles mixed with the base fluids. The size of the solid particles used for the suspension is far enough to not to settle down as what happened with micro meter sized particles. Though nanoparticles possess the issue of agglomeration (settling down in the base fluid) it can be used as next generation heat transfer fluid with the technologies available to reduce the agglomeration which thus increases the stability of the nanofluids.

Higher heat transfer of the heat exchangers used for various applications can be obtained using swirl flow devices such as inserts inside the tube. Recent studies show that the better heat transfer rate can be achieved with the inserts as compared to those plain tubes with no much cost and design considerations. As the flow inside tube gets disturbed by the swirl flow devices, secondary flow starts inside the tube which increases the time of the coolant inside the tube thereby increasing the heat transfer rate of a heat exchanger.

Maughal Ahmed Ali Baig et al (2013) experimentally investigated the overall heat transfer performance of suitably designed concentric tube heat exchanger with passive heat transfer augmentation technique. [1]. A. G. Matani et al (2013) determined the influences of twisted tapes on pressure drop, friction factor, heat transfer and thermal enhancement index experimentally. [2]. Khwanchit Wongcharee et al (2012) investigated the heat transfer enhancement by using CuO/water nanofluid in corrugated tube equipped with twisted tape experimentally. [3] Syam Sundar et al (2007) experimentally determined the thermo physical properties of  $\gamma$ -  $\text{Al}_2\text{O}_3$  nanoparticles in deionized water at different volume concentrations ranging from 0.2 to 0.8.[4] .Smith Eiamsa-ard et al (2011) experimentally studied the heat transfer, friction and thermal performance characteristics of CuO/water nanofluid.[5]. S. Suresh et al (2011) experimentally investigated the comparison of thermal performance of helical screw tape inserts in laminar flow of  $\text{Al}_2\text{O}_3$ /water and CuO/water nanofluids through a straight circular duct with constant heat flux boundary condition [6].

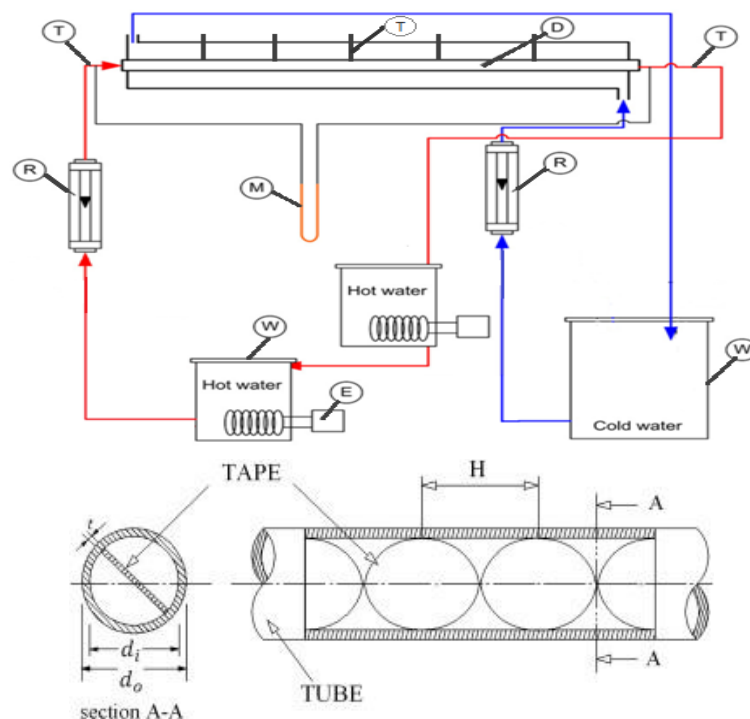
Sarada et al (2010) experimentally investigated the frictional and heat transfer characteristics in turbulent region using varying width twisted tape inserts under constant wall heat flux in a horizontal tube with air as the working fluid. [7]. P. Razi et al (2011) measured the heat transfer and pressure drop characteristics of nanofluid flow inside horizontal flattened tubes under constant heat flux experimentally[8].Patil et al (2012) experimentally investigated the heat transfer and friction factor characteristics in a double pipe heat exchanger with cold and hot water were used as working fluids in shell side and tube side fitted with straight delta winglets twisted tape at different twisted ratios ( $y/w=3.5, 4.5$  and  $5.5$ ) and depth of cut ratios ( $d/w=0.1, 0.2$  and  $0.3$ ), and typical twisted tape with twist ratios ( $y/w=3.5, 4.5$  and  $5.5$ ).[9] Zamzamian et al (2011) experimentally studied the forced convective heat transfer coefficient in nanofluids of  $\text{Al}_2\text{O}_3$ /EG and CuO/EG in a double pipe and plate heat exchangers under turbulent flow and evaluated the effects of particle concentration and operating temperature on the forced convective heat transfer coefficient of the nanofluids.[10]

This project work includes the combination of nanofluid and twisted tape insert to enhance the heat transfer coefficients of the double pipe heat exchanger as both serves the purpose of higher heat transfer rate.

## 2. EXPERIMENTAL SETUP

The Experiment layout consists of a double pipe heat exchanger along with two separate tanks for hot fluid and cold fluid. Thermocouples of K type were used to measure the temperatures at various positions. A 1500 W electric heater was utilized to provide the desired hot water temperature. Experiments were conducted in the double pipe heat exchanger fitted with full length twisted tape, by varying the Reynolds Number from 1750-7000 in the counter flow arrangement. Initially the experiment was conducted using water at 33°C as cold medium and water at 66 °C as hot medium without insert in laminar and turbulent region. Two Rotameters were used to measure the flow rates of both hot and cold fluid.

The temperature at different locations of the inner tube surface was measured by the thermocouples fitted at various positions using digital temperature indicator. The outlet temperatures of both hot and cold fluid were also measured. The same procedure is followed for the Nanofluid. The temperature of Nanofluid is maintained at 33°C while the hot water temperature is maintained at 66°C as in the previous case. After that the twisted tape is inserted inside the inner tube. The same procedure is repeated for both water and nanofluid while the inlet temperatures remain same as that of previous readings. The readings were taken and tabulated for both water as well as for nanofluid.



**Fig. 1 Schematic Diagrams of the Experimental Setup**

W - Water tanks,  
M - Manometer

R - Rotameters,  
T - Thermocouples

E - Heater

### 3. RESULTS AND DISCUSSION

Thus, the experimental analysis on the double pipe heat exchanger has been done with twisted tape insert using nanofluid. The readings were tabulated for water as well as for nanofluid with and without twisted tape insert.

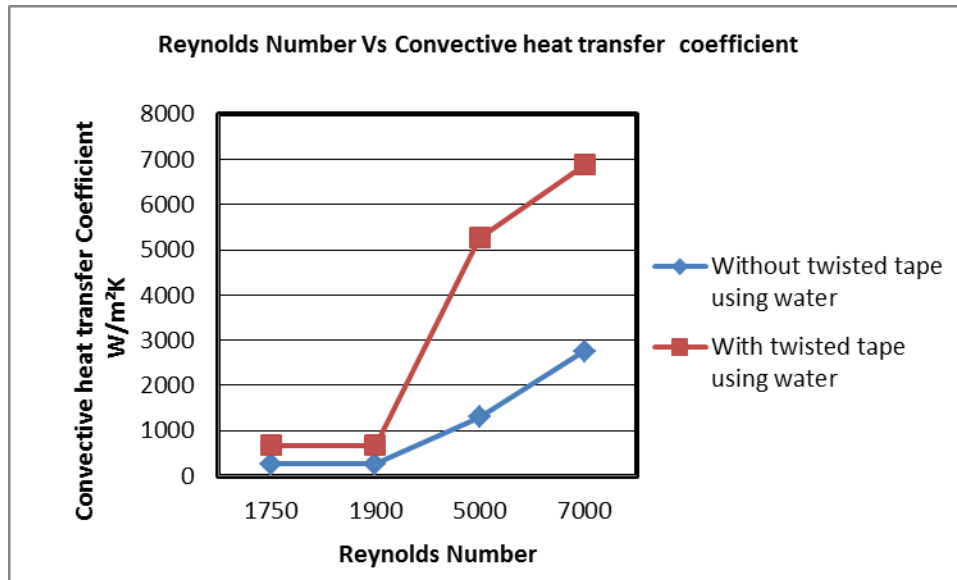


Fig. 2 Reynolds Number Vs Convective heat transfer coefficient for water

Fig.2 shows the comparison of convective heat transfer coefficient and Reynolds number with and without twisted tape using water as cold medium. It is found that the use of twisted tape enhances the convective heat transfer coefficient with increasing Reynolds number while using water. This is due to the swirl flow caused by the twisted tape insert as it increases the repository time of the coolant present inside the tube.

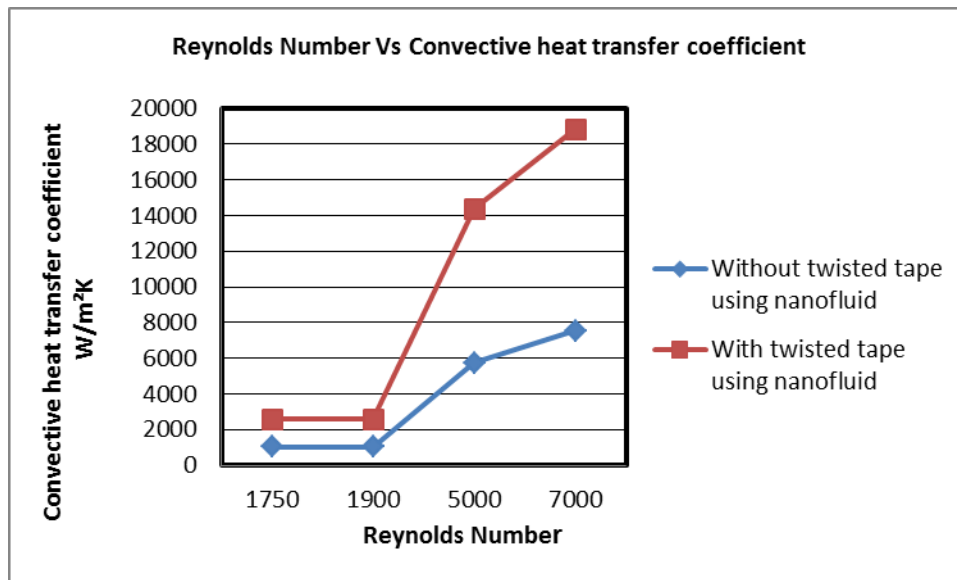


Fig: 3 Reynolds Number Vs Convective heat transfer coefficient for nanofluid

Fig.3 shows the graphical representation between Reynolds number and Convective heat transfer coefficient with and without twisted tape while using Nanofluid. It is found that the use of

twisted tape insert while using Nanofluid increases the convective heat transfer coefficient with the increase in Reynolds number. From the results obtained experimentally, the use of Nanofluid with twisted tape insert increases the convective heat transfer coefficient as compared to that of water with twisted tape insert.

From the results obtained,

- ❖ The combined use of twisted tape and nanofluid increases the heat transfer coefficients than their individual uses in the heat exchanger.
- ❖ It was found that the use of twisted tape alone enhances the convective heat transfer coefficient by 6% as compared to that of plain tube while the use of nanofluid alone enhances the convective heat transfer coefficient by 7.5% as compared to that of water.
- ❖ While combining these two techniques, the convective heat transfer coefficient enhanced by 18 % as compared to that of plain tube with water in the double pipe heat exchanger.

#### **4. CONCLUSION**

In this project work, the experimental analysis on double pipe heat exchanger with twisted tape insert using nanofluid has been carried out. It was found that the use of twisted tape alone enhances the convective heat transfer coefficient by 6% as compared to that of plain tube while the use of nanofluid alone enhances the convective heat transfer coefficient by 7.5% as compared to that of water. While combining these two techniques, the convective heat transfer coefficient enhanced by 18 % as compared to that of plain tube with water in the double pipe heat exchanger.

Further work can be done by varying the nanofluid concentration, twisted tape geometry and Reynolds number in the double pipe heat exchanger.

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